Menlo Park Notebook #17 [N-79-04-21]

The dated entries in this book begin on page 75 and cover the period April-November 1879. The earliest entries are a series of undated notes by Edison relating to the work of Sir William Crookes on vacuums, which are followed by drawings of vacuum pumps. These entries probably relate to a series of vacuum experiments for electric lamps, conducted in February and March 1879. The rest of the book is by Francis Upton and relates to electric light experiments. Included are notes, calculations, and tests on generators, motors, and batteries; drawings of generators; calculations about electric light systems; and notes on a regulator "to make a ten ohm lamp equal to an 100 ohm." The label on the front cover is marked "Theory" and "Upton." The book contains 284 numbered pages.

Blank pages not filmed: 20-21 46-47, 234-249, 280, 283.

Missing page numbers: 281-282.

176/7

GENERAL ELECTRIC.
Schenectady, N.Y. U.S.A.
May , 189 c

Crokes says monohydrated Sulphuric acid evolves vapor He replaces it with Phosphoric anhydride for drying the gases he says nothing about washing it the pumps with it. yet he used the former for that purpose.

He use a tube stuffed with gold leaf between the receiver & the Vacuum bulb.

He sometimes uses air absorption to carry Vacuum still further.

working with air he finds that at
a pressure of 40 millimetres of an Atmosphere
a spark whose striking distance
at the normal pressure is 1/2 an
inch, will illuminate a tube having
aluminium terminals 3 millimetres
apart. but when he pushes the
exhaustion still further the 1/2
inch spark ceases to pass but
a 1 inch spark coil will still
illuminate the tube.
The nearer he gets to a vacuum
the more power it requires to drive
the spark through the tube but at
the highest exhaustions he still
gets indications of conductivity
when he uses a 6 inch spark
coil. = With such coils there is
a tendency of perforating the glass
& give a slight cracking of
the —

he says that these perforations are so minute that it take several days to show themselves –

He exhausts down to 2 millionths of an atmosphere –

He keeps the vacuum pump during exhaustion in a hot air bath heated to 300° C. for some hours to drive off the occluded gases from the interior surface of the glass – perhaps our ~~Equal~~ will accomplish this

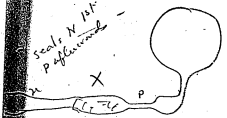
Use burnt India rubber on his stop cocks – he melts it & lets it fall on the ground surface –

stoppers not near so good as sealing

Uses an geissler tube single points standard Carl & Sachs to judge of the progress of the vacuum -

This becomes uniformly luminous as you go higher its becomes obliterated Then Luminous at the poles only then black & non conducting -

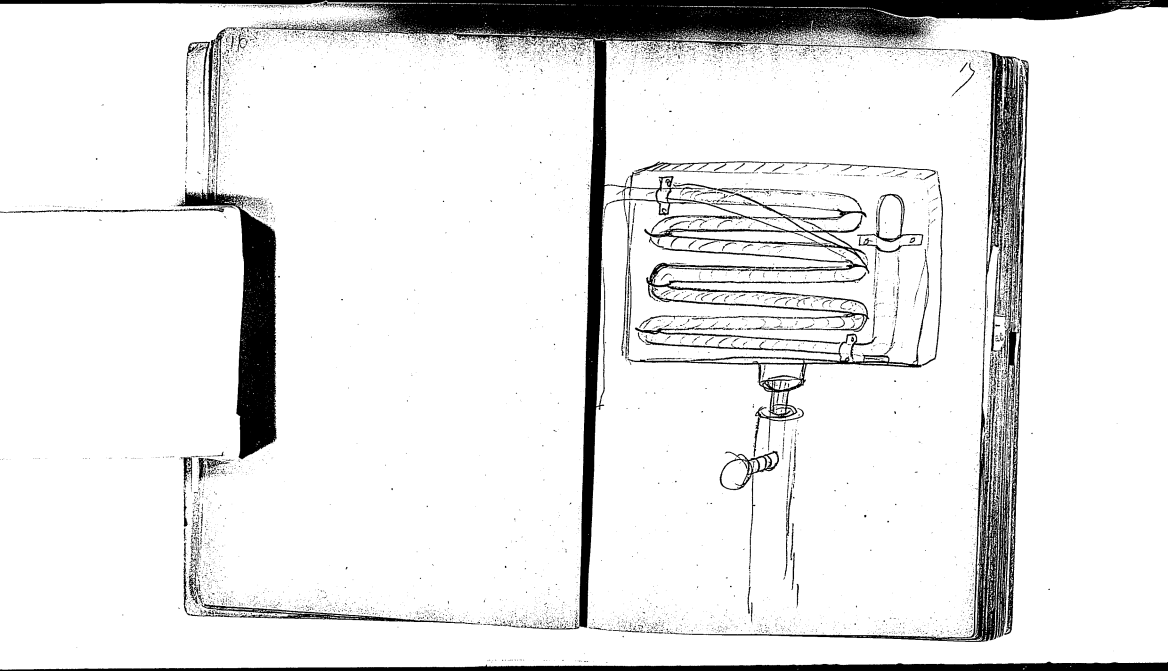
Crookes seals his platinum wires in long small tubes & these he seals in the main tube, this he says is requisite to prevent leakage —

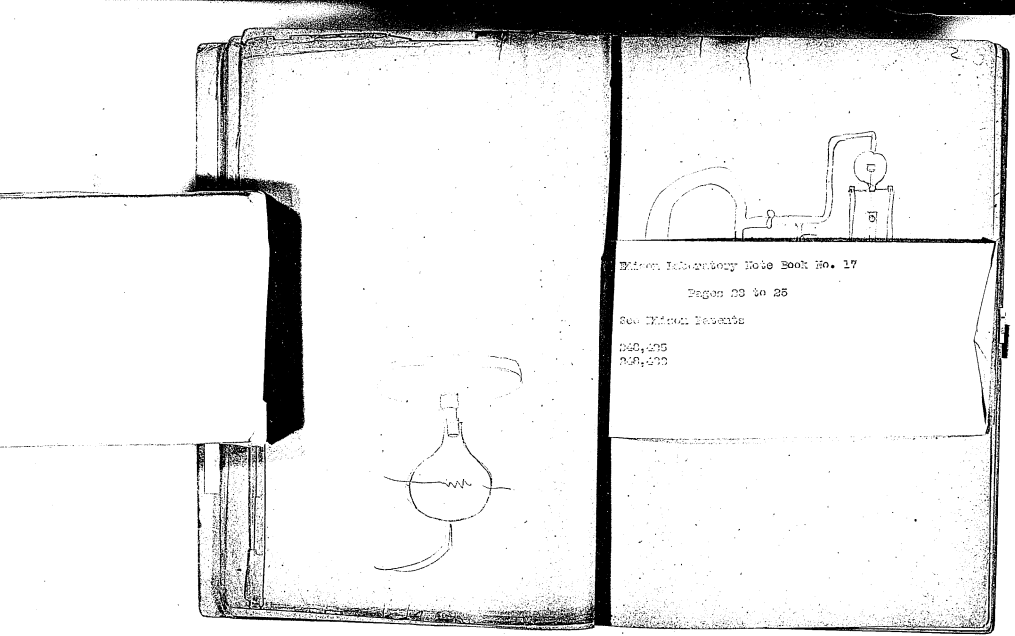


Uses cocoanut charcoal in X. Exhausts & then leaves for 24 hours or more so that the Charcoal will absorb all the residual gas then seal this off.

uses a tube 6 inches long
tightly packed freshly ignited
Cocoanut-shell Charcoal.
After vacuum the charcoal tube
is heated nearly to the softening
point of glass when the occluded
gases are given off from the
charcoal & depress the Mercury
gauge 30 to 40 millimetres.
The pump is worked rapidly
till gauge is brought up
again, the heating of the
Charcoal is repeated when more
gas is given off & the gauge is
again depressed although not
so much as before this is
repeated until the heating

the Charcoal ceases to
depress the gauge
Then the whole is sealed off
leaving Charcoal in connection
then set aside for some weeks
When the Charcoal will absorb
the whole of the residual
gas & leave the vacuum so
perfect that it will not conduct
an induction current, then
Charcoal tube & then sealed off



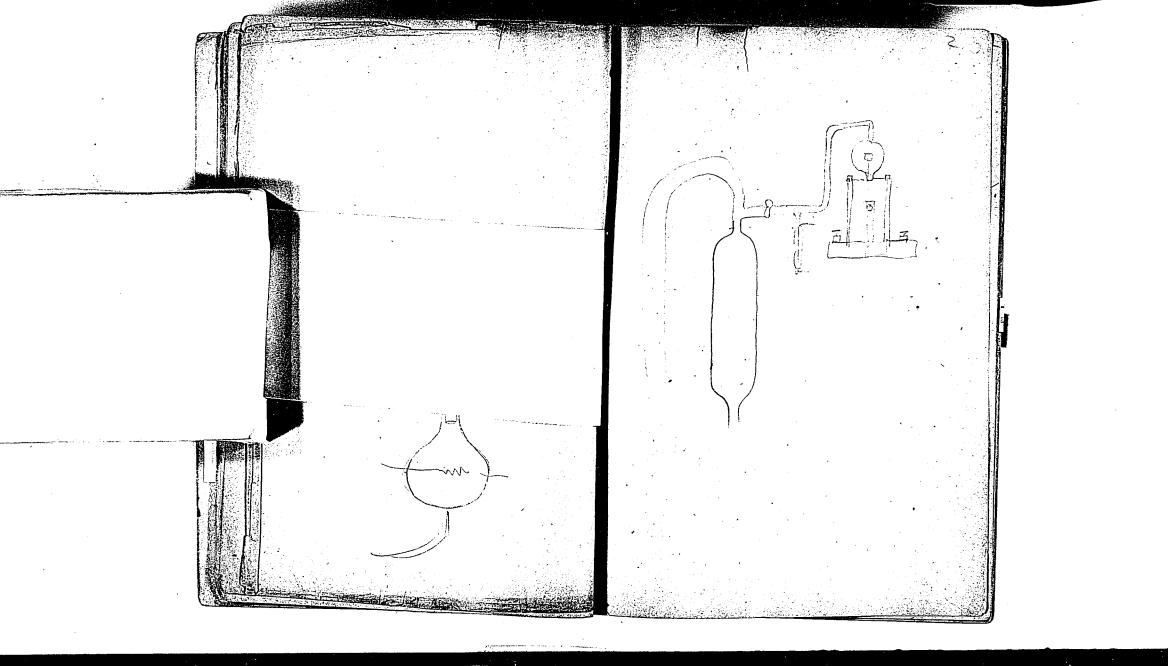


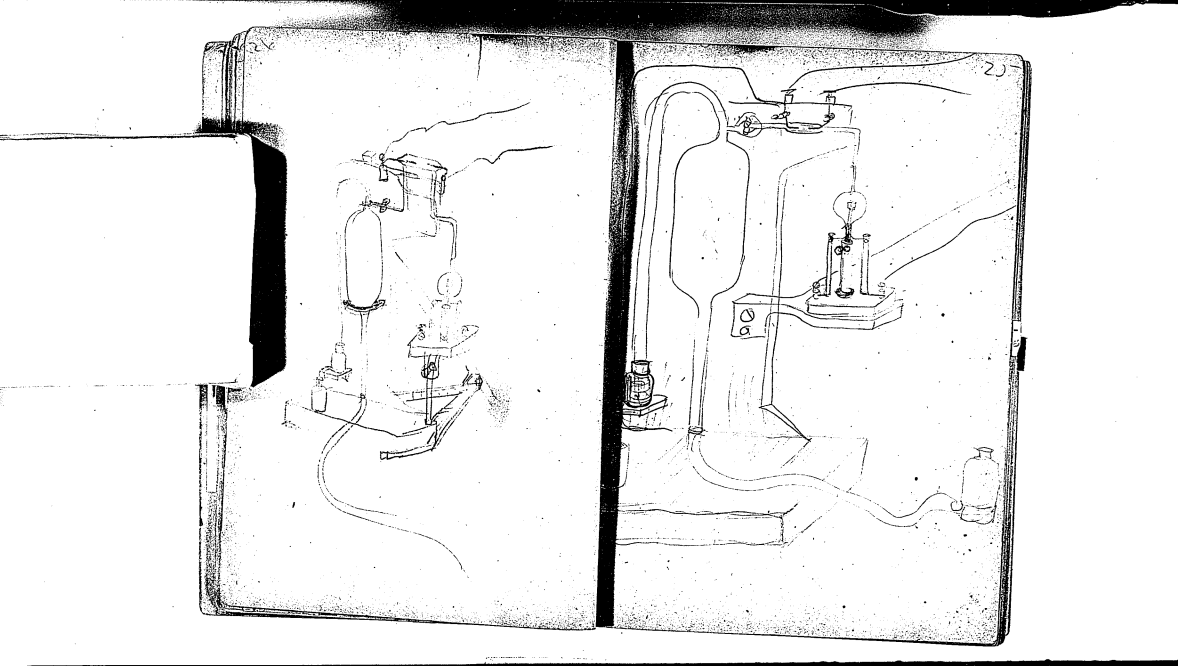
Wilson Laboratory Note Book No. 17

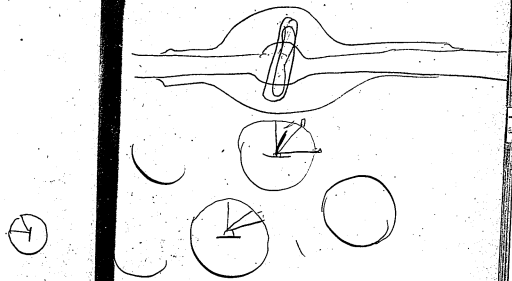
Pages 22 to 25

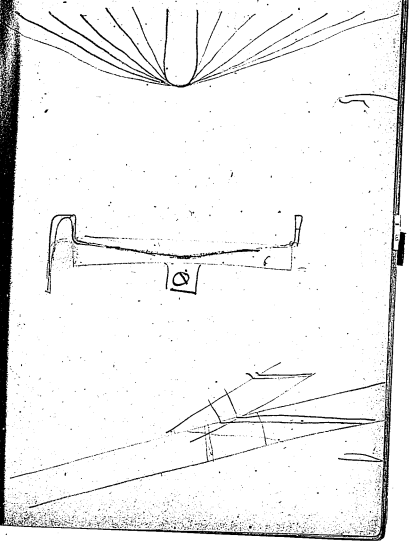
See Wilson Patents

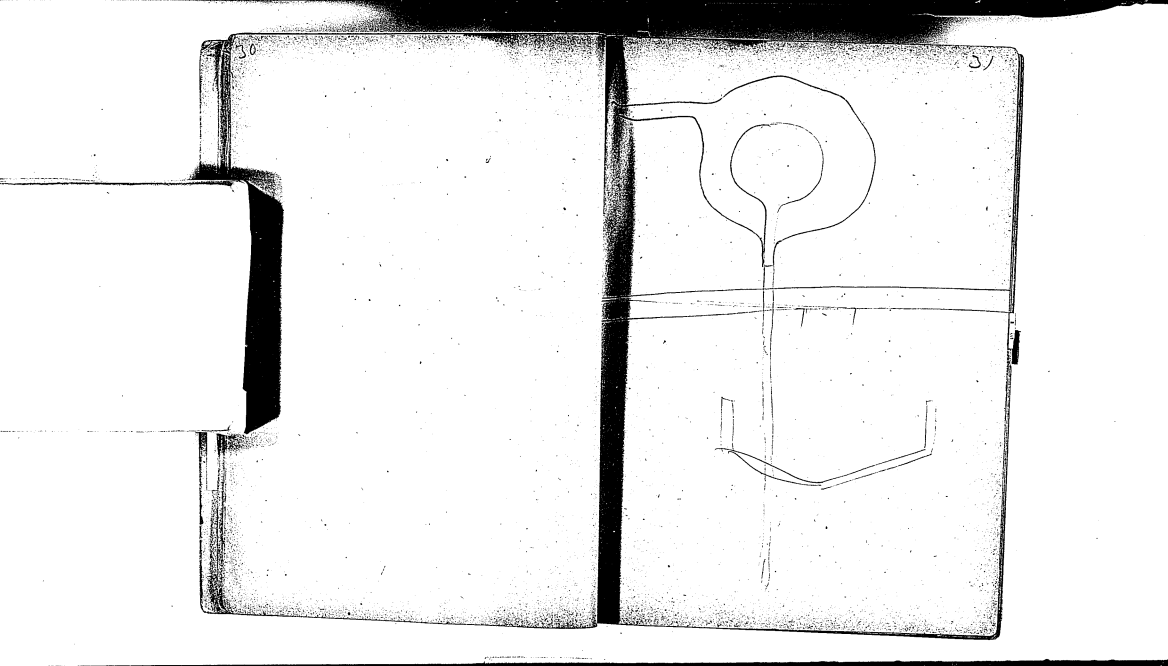
320,295
320,270

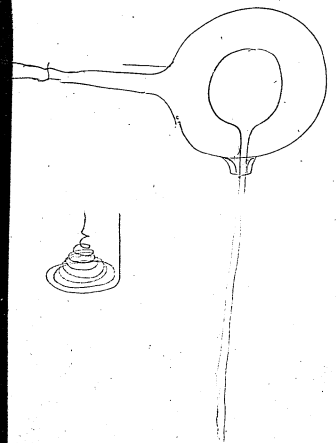


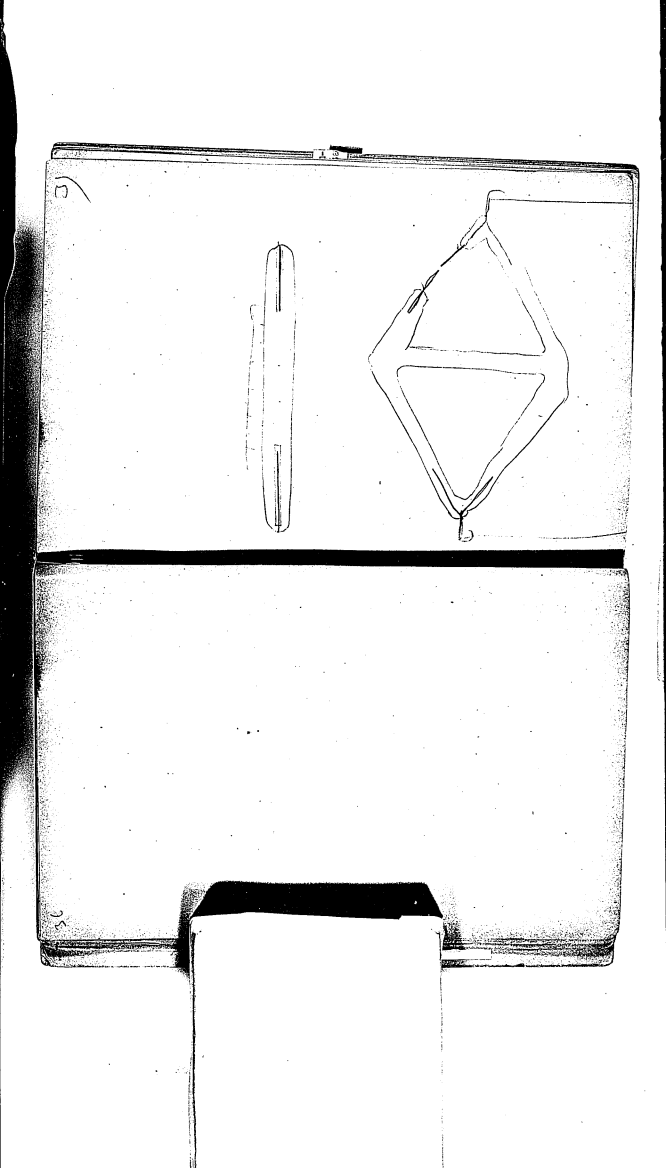


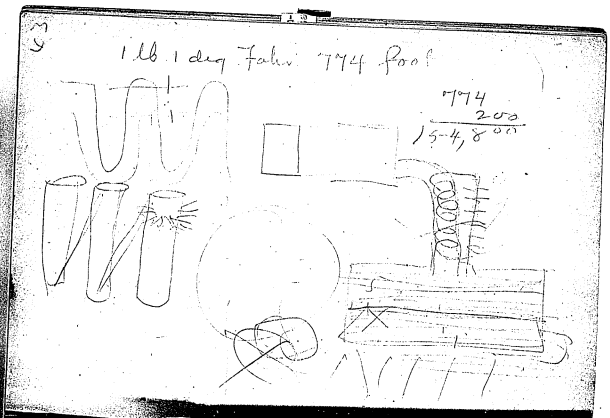


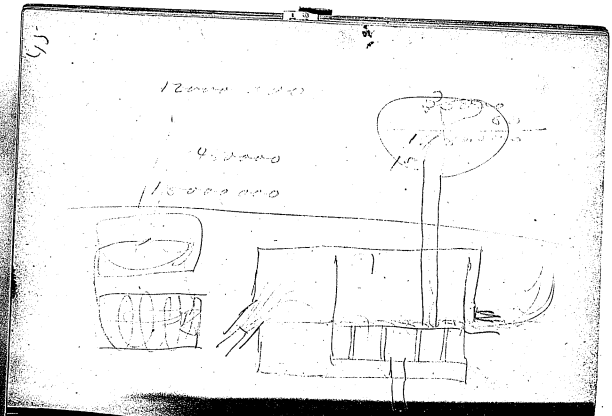


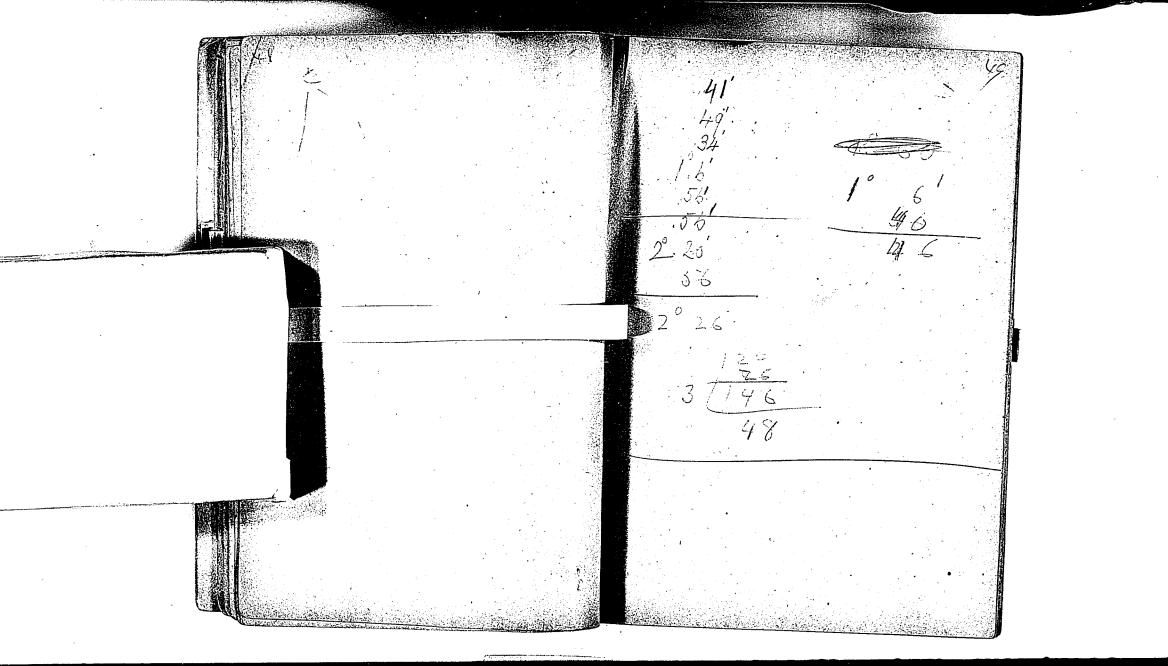







1 lb 1 deg Fahr 1774 Proof
1774
200
1574





Let it up where wanted

Prepare Shunt for Silver

About .07
wire about .05
Line 1.17

Paint

3000

3000

6000 ft lbs per minute

10

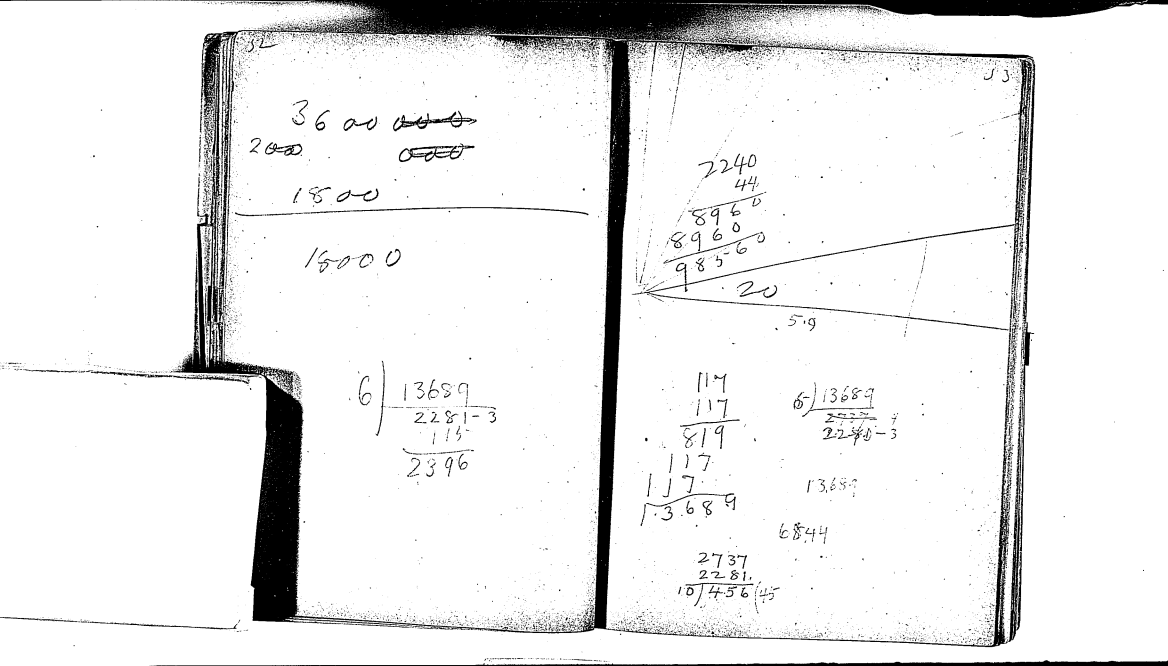
600

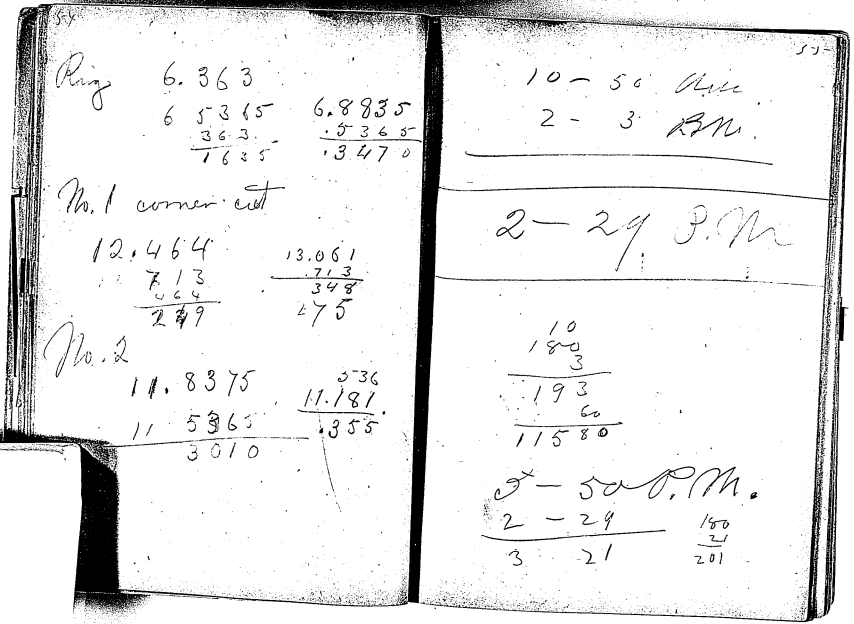
3.6 ~~0 0 0 0 0 0~~

33 ~~000~~

108

60) 10.8


SL
3600
2000
1500
15000
6 | 13689
2281-3
115
2396
SJ
2240
44
8960
8960
9856
20
5.9
117
117
819
117
117
13689
13689
6844
2737
2281
10 | 4561 45



5x

Ring 6.363

6 5 3 6 5

3 6 3

7 6 2 5

6.8935

5 3 6 5

3470

No. 1 corner east

12.464

7 1 3

5 6 4

2 9 9

13.061

7 1 3

3 4 8

4 7 5

No. 2

11.8375

11 5 3 6 5

3010

5 3 6

11.181

3 5 5

5x

10 — 50 A.M.

2 — 3 P.M.

2 — 29 P.M.

10

180

3

193

60

11580

3 — 50 P.M.

2 — 29

3 21

180

21

201

.275

.275 Grammes

log .275 1.4393
Colog 11580 4.0637
5.3756

.0006237

.00326 3.5132
5.3756
137. 2.1376

1 Danielle on about 137 ohms
On reality there was not
more than 13.7 Ohms

Battery 2 ohms
3
2
6 ohms
Perhaps commute S. M. F.

− 2° 40′
+ 5′
2° 45′

+ 3° 25′
2° 40′
6° 5′

58

120
45
165

6
60
360
5
365

165 2(2.2175
1.1087
7901
.3186.

2,08

12.6

.3186
1.1871
1.5057

32.0 Webers

Grammes vers 1.4 autres
24 total

54

0 2° 32'
2 8
24'

2 = 2. m. 7

2
.13

.13) 2 0.3010
.13 1139
1.1871

15.4 Webers

24 2(1.3802
.7901

60

32 1.5705-7

2.4 0.3802

1.8859

42. 1.5057

1.6232

5.0148

102,000.

5.0148

33000 4.5185

.4963

3.1 H.P.

740 revolutions

24

16

20 24

6 16

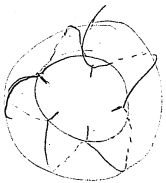
188 24/16 X 5/20/6

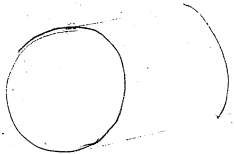
940 4

Measure the machine
~~[illegible]~~ a circuit
when warm.

To determine the E. D

-.44'
+ 2
46'





66

77

4.331

.061

2 (2.356
1.178

3.6

36

65

305 mm Diameter
152.4 in Radius

$\frac{1}{50}$

$\vartheta = \frac{e}{2\pi} H \cdot tg\alpha$

$H = 2.06 =$	0.3139
$b = 152.$	2.1818
$tg\ \alpha = 3°36'.061$	2.7853
comp $\frac{1}{50} =$	9.5036 −10
comp 2π	9.6990−10
	0.4836
	2.7853
	1.6978

3.0

$\frac{3}{10} = .3$ Webers

Since Point Res unit of E.M.F. is 1/10 of Webers

.6978

66

Large plate

102.5 ft 4

Small plate in dish 3.5 Ohms

Small plates 3.6 Ohms

Weight

67

No. 1 corner cut

13,004
12,674 5
329 5

No 2

10,864
11,186
322

Fresh carbon cells
Through 3.6 Ohms

4-35 P.M
8° 20'

4-42 9°

5 P-M
8°

$\theta = \frac{G}{2\pi} H \operatorname{tg} \alpha$

$H = 2.06$
$G = 152$
$\alpha = 9°$

comp 2 Page 65 1.6978
cond π 9.1997 - 10
.8975

7.89

7.89

.789 Webers

if Volt = 10^{10} $\frac{\text{Wm}^2 \text{ Ohs}}{\text{Sec I}}$

Voltameter

.000 326 Grammes / Weber
1 second

.325 Grammes

25 minutes
60
75 00 seconds

log .325 = .00 1.000.
Comp .000 326 .000000X
Comp 1500

1000
1500

2/3 Weber .666 Webers

2/3.6 2/3.7 Weber

E = 2.2
R = 3.7 Ohms

Ohms

3.7 2 2 1.13424
37 1.56582
T.7742

.594 Webers

72

Ring 4.3007
4.655
3097

no.1 12.625
13.4175
.7925

no.2 11.186
10.3775
.7985

73

3.3 Ohms Basin

3.6 Ohms Plates

Put on 8-53 P.M.
290
8-55 28° 30'
9 1 28 05'
29°
29° 15'

9-28
35 Minutes

Galva constant

Range 65 1.6948

log .2845 9.7392 − 10

1.4370

27.3

2.73 Webers

$\mathcal{E}$ = 4.2 Volts

Resistance = .2 + 1.7 = 2.7

2.3.4
1.7

4.2 / 2.7 .6232 / .4314 / .1918

1.55 Webers

Could not determine from the deposition of Cu on the current was so strong as to deposit it in granules.

April 21 1879

Determination of the Constants of Tangent galvanometer

Heavy plate 109 mm by 92 mm

76 April 21 1879

Large plate
Corner cube

98.625
99.808
1.183

1,153
1.1 cos.
2.2838

86.178 2
37.279
1.1008

2 small plate
No. 1 corner cube

13,4155
9.6365
3.7890

No. 2

10.3517
14,061
3.7093

1 cell corrections

274

77

Through

240

3700
3
22205
14 m - 0
36 200

277
27
247

Not on Zero

78

1 Daniells cell
3600 Ohms + Galvanometer

65 to the left
74 to the right

2)139
695

Shunted on 1 Ohm +

19 to the right
19 to the left

3)69.5
23.16

76 to the left
76 to the right

77

1 Carbon cell

220 to right
210 to the left
210 to the left
220 to the right

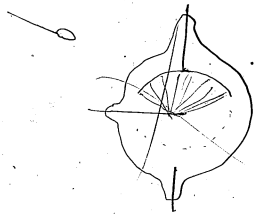
0 at zero

Through the galvanometer and 1 Ohm.

187 to the right
181 " " left

Deflection Tan. gal.

190 151



60° 30' tan +65°

Short circuit

65 to the left

58° 30'

59 to the right

57° 30' +1°

55 to the left

53 to the right

185 to the right

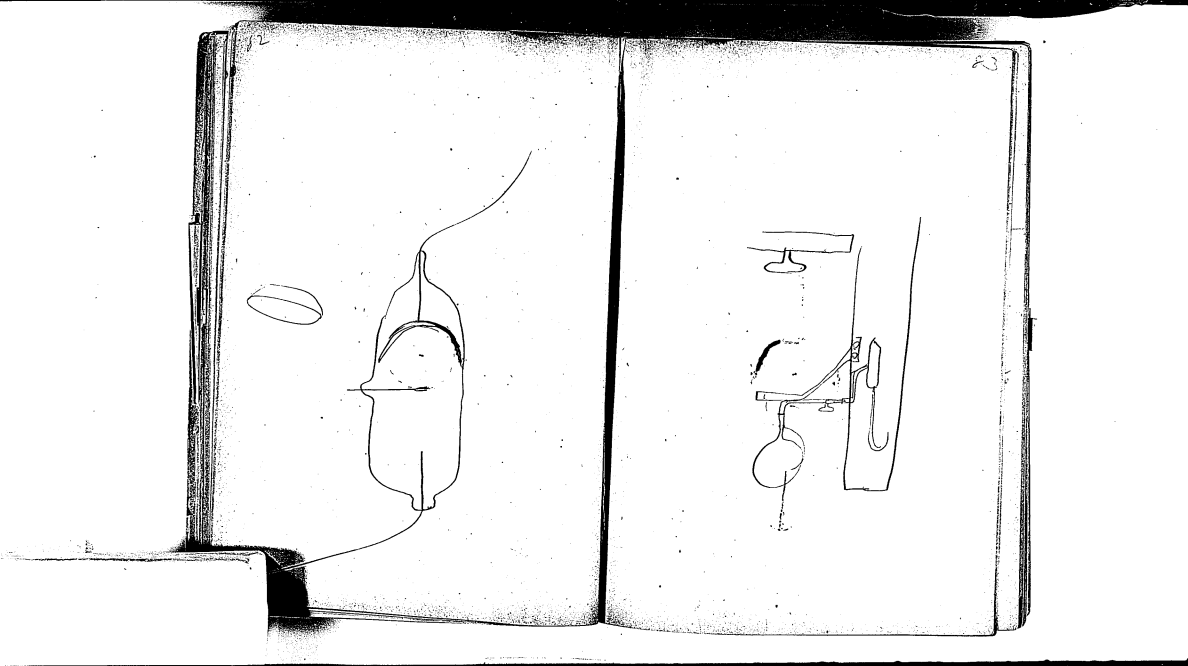
195

195 to the left

205 to the right

About 5 minutes

Under the battery



Cathode

200

Another cell

200 to the P

Another determination

205 to the left

213 to the right

205 to the left

203 to the right

Through 10 ohm & Galvo

175 to the left

175 to the right

175 to the right

18° 30'

Ghost circuit

55 to the right

~~55 to the left~~

58°

55 to the left

57 30'

50 the right

56 15'

195 the right

200

204

193 to the left

200 to the left

198

210 to the right after five minutes

203 right

205

Resistance

107
5
1.02 Ohms

Daniells

60 to the left

30 to the right

65 to the right

70 " " "

Zero changed

~~Carbon~~ Carbon

207 to the right

198 to the left

again zero and these numbers

207 to the right

Carbon on 102 Ohms

175 to the right

20° 15' ≠ D

166 to the left

18° - 45'

Short circuit

50 to the left

58°

48 to the right

700

45 to the

57°

---

after short circuit

175 to the right

Fresh Carbons

215 to the right

205 to the left

420

210

Poor Daniells plain cork

65

Good Daniells

106 to the right

105 to the left

103

~~100~~

104

Carbon 216 right

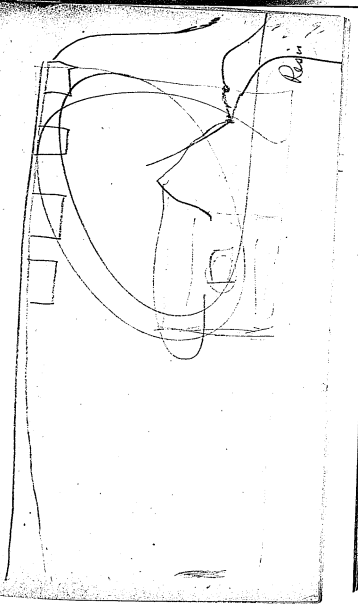
208 left

90

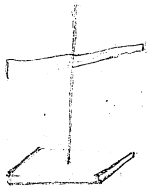
Results

Daniells 105 Ω

Carbon 280 Ω



92



53

Wt of round Cu

~~4.4025~~

4.3155

6-13 P.M

on .05 Ohm shunt

5.7 Ohms E.M.F. assigned

The correct

11 a.M.

4.317 Wt of rod

.0025 in grooves

in place of short

.037

contrary E.M.F.

Dynamometer

2° 26'
1°
1 26
60
56

2°. 30
1°
3°30
180
210

1° 30'

1° 43'

+ P 29'
56
33' on Dynamometer

40° 30' on Galva

36° 45' on Galva

29'
27

57'
27
30'

52
24
28'

50'
51' Does diminish
28'
23'

55'
28
27'

545
26
28.5

51'
12
40

2 cells of Carbon through
Galv. Dynam and about .90 ohm

54
25
29

High resistance galvanometer
around

305 to the Rt

140 to the left

2 cells carbon

220 to the left
230 to the right

620 Radius

225 2.3522
620 2.7924
9.5598 -10

.363 tan 20° = .363
20° R = 1

.74 Ohm in shunt
round galvanometer

2 Carbon cells have each 2.1 V.
of 2 Daniells or about 2.1 Volts
Total 4.2 Volts

225 = D

225/4.2 23522
.6232
17290

53.5 D for 1 ~~Volts~~ Volt

over .74 Ohm

April 21

40	2.1461	
53.5	1.7284	
	.4177	

2.6 Volts over .74

$C = \frac{E}{R}$	2.6	0.4177
	.74	1.8692
		.5485

3.54 Webers

4.2	0.6232
3.54	0.5490
	.0742

1.18 Ohms in circuit
or the battery polarizes since
there are External .86 Ohms
and internal .2
1.06 Ohms in circuit

April 22. 59

3 Ohms in circuit with
two carbon batteries.
two cells of Voltameter

10 dash.

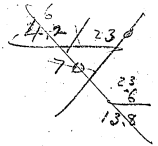
24° 30' tan. galvanometer

High Resis Sol
70 to the right
.68 Ohm
Shunt

took off 11—5
2 Carbons direct
214
215
230.

.68 Ohms in Shunt

2 carbons have E.M.F. of
4.2 Volts



$\frac{4.2 \times 700}{230}$ $\frac{4.2}{7}$ 29.4

29.4 1.4683
23 1.3617
.1066

1.27 Webers

Ohms Volts Webers

3.2) 4.2 (1.31
32
100
96
40

$\frac{210 \times 42}{230}$

21		1.3222
4.2		0.6332
comp. 23		8.6385
		.5937

3.92

3.92	0.5937
3.2	0.5051
	.0886

1.23 Webers

Amt deposited in 65 minutes 2.284 Grammes

See page 76.

	2.284	,35588
comp	65	8.1871
comp	60	8.2218
comp	.000326	13.4868 - 10
		0.2545

1.8 Webers

60	8.2218
.000326	13.4868
	21.7086 -20

Tan Page 65

Tan. Gal. constant 0,6978

Log tan 24°30' 9,65587

.3565

2.27 Webers

1,23 Best
1.8 Good
2.27 " for nothing
3)5.30
1.76 Webers average

I do not understand why these results are so far apart

I think the method with galvanometer of high resistance is the best

Trial April 22 of a g. in Pt. Crucible with Daniells

Wt of Pt Crucible

15.8975
16.2245
.3270

Daniells 171 to the left

2 6 P M

D = 48 left

Zero at 1 to the right

D = 42

R = 605

Taken off 2-46 P.M.

2.85 Ohms in Pt crucible
7
2.78 Ohms

2.04
7
1.97 Ohms in Shunt

2.78
4.75
2.00
6.75 in all

Silver April 28

40 mumble

.3270 Ag

.3290	T 5.145
Comp 2400	5.6198 — 10
Comp .001116	12.9508
	T.0851

.121 Weber

Galvanometer

42	1.05
172	1.97

.42	1.6332
1.05	0.0212
Comp. 172	7.7645 - 10
Comp. 1.97	9.7055 - 10
	19.1244

T.1244

.133 Weber

Total circuit

1.05 Volts	.0212
6.75 Ohms	8.293
	T.1919

.155 Webers

This seems to be more nearly correct yet far from exact factory. Shall now try two coils of Daniells using silver and Cu. voltameter

Silver April 28

40 minutes

.3270 Ag

.3290	Ts 145
Comp 2400	5.6198 — 10
Comp .001116	12.9508
	T.0851

.121 Weber

Galvanometer

42	1.05
172	1.97

42	1.6332
1.05	0.0212
Comp 172	7.7645 - 10
Comp 1.97	9.7055 - 10
	19.1244
	T.1244

.133 Weber

Total circuit

1.05 Volts	.0212
6.75 Ohms	8.293
	T.1919

.155 Webers

This seems to be more nearly correct yet far from satisfactory. Shall now try two cells of Daniells using silver and Cu. voltameter

April 23. 1878

Cu ~~plate~~ disc Ag put in same circuit 1 Daniells

Wt of corner cut Cu

~~31.0215~~
31.1965
31.6865
.4900

Cu
31.449
30.940
.509

.498

Cu
16.180
17.8715
1.6905

Ag
Ag 126 12.9508
8.2218
21.1726
7.5591

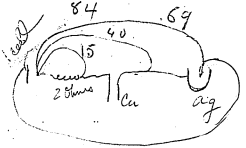
Comp 1.6905 9.7721
.498 1.6972
.001116 3.0473
5.5166-10

.000328 in place of .000326

time 10-37
Estimated 3.9

Current around 2 ohms
15° to the right
E.M.F in 2 ohms

15/84 .69



240
36
276
60

25
84.5 X 2
Cu per minute 1.7086
Comp 276 7.5591-10
1.6972
9.9649-10

1.1761
8.6731
9.6990
.91482
1.1482
= .14 Webers

Constant of Galvanometer

Time 11 - 15 A. M.
started 2 - 20 P. M.
$\delta = 22° 15'$
$D = 20'$ 11.27 dyn
Page 76 $H = 18°$ 1.25 G. M.

Wt of plates
comm cut 99.808 Grammes

10 2.625
2.817

120
65
185

37.279
40.1045
2.8255
2.817
5.6425

I find the current through the tangent galvanometer of one coil. Through a Voltameter with two cells in multiple arc. Through the Sygnamometer and

Ohms

A galvanometer having 39.00 Ohms outside and Ohms internal is placed in a Shunt having Ohms, the galvanometer being placed on a shunt

Around Ohms is placed a circuit having 36.000 Ohms and high resistance differential galvanometer. This measures the current in E. M. F. on the shunt and from this the current may be calculated

2 Daniell cells
204 to the right

1 Daniells
99 to the right

1 Daniells 100
100 to the right

2 Daniells
204 to the right

Changed the Galva
2 Daniells
170 to the right
1 Daniells
84 to the right

Another
1 Daniells 85 to the right
84
169

Zero

Reversed
2 Daniells
169 to the left

1 Daniells
84 to the left
1 Daniells
85 to the left

1 95 = D to the right
over shunt of
tan Gal 18° 30'
29'

The plates

205
96
109 = D & d right

Jan 17°-

83 deflection

.71 Ohm .68 Ohm

.37
.34

43
through .37 Ohm

	.68	T. 8.3325
a	43.	1.6335
	83.	8.0809
		T. 5469

.352 Ohm calculated

comp	83	8.0809
	.68	T.8325
	109	2.0374
		9.9598 -10

.91 Ohms in Voltameter
calculated

There was no current

$$\frac{83 \quad 1.04}{84.5} = \text{E. M. F.}$$

$$C = \frac{\varepsilon}{R} = \frac{\varepsilon}{.71}$$

log	83	1.9191
	1.04	0.0170
comp	84.5	8.0734
comp	.68	10.1675
		20.1769

1.5 Webers

5.642 Grammes Cu deposited in 185 minutes

5.642		0.7515
comp	185.	7.7328
comp	80.	8.2218
comp	.000326	13.4868
		30.1928

1.55 Webers

Galva

Page 65		1.6978
19° 30′		9.5491
		1.2469

1.76 Webers

17.6

Platinum Crucible

10.
5.
.500
.200
.010
.007
15.717

Copper No 1

50.
20.
10.
10.
.2
.1
.500
.200
.100
.008
93.808

Copper No 2

50.
20.
10.
10.
5.
1.
.100
.020
.002
96.122

Copper No 3

20
10
5
2
2
.500
.250
.050
.05
39.7655

97 1533
1 93.808
3.3453

43 1355
3 39.7655
3.4700
3.4121
2 6.8921 0
3.4455

Copper No 4

100.
2.
.200
.050
.010
.008
102.268

2 96.1228
92701
3.421

4 102.2685
98.833
3.4355
3.3453
2 1.67808
3.3904

97 right
96 left
Daniells
conc cu
1641/2504

96 right
95 left
Daniells

April 24, 1878.

1 Daniells
90 Right

Chg 24

Put on 8—21½ A-M

18° on Tan Galvan.

11—10 Acme

13° on Tan Galva

13° on Tan Galva

- Cu. Cell

Taken off 12-56 M

total Cu 3.44555

3.39704

64359 0.8035

56
39
180
275 rounds

camp 275 7.5607

17.0786

10.0728

.0728

1.18 Wolfers

1.23

Copper No 2.

50.
20.
10.
10.
9.
550
250
301 9/11

92.701 9/11

Copper No 3

20.
10.
10.
2.
1.
.25
.10
1005.5

43.135.5

Copper No 1

50.
20.
10.
10.
5.
2.
1.
583

97.153.9

Copper No 4

10
20
10
10
5
2
1
500
200
100
20
10
8

98.833.

1 Daniells
124 left

4 H_2SO_4
$CuSO_4$ Crescent
127 Right
125 left

1 Daniells
122 left
125 right

2 Daniells
235 right
117 right
117 right

.33
45
two 90

Again
Daniells
117

Again Daniells
114 right
114 left
114 right

2 230R. 114
228

Standard cells

125

Daniells

124 night
124 R

---

228 2 cells
124
124

360
120

2 cells 240 night

2

difference between the Daniells.

1 cell 114
another 125 R
126 R

Standard

Cu SO_4
114 H_2SO_4

gives 128 R
126 R
129

14° on tan Gal

44R = D over

44R =

89.5R = D ow

12 .32 Ohm
.33 Ohm

.65 Ohm

E. M. F

$\frac{44 \times 1.079}{126.} = E$

$\frac{E}{.32} = C$

1.6435
0.0330
7.8996 −10
10.4949 −10
.0710

1.17 Webers

14° .93967
.16978
0.09745

1.23 Webers

14° 1.17 Webers

19° 1.525 Webers

	1.17	.0682
comp to 14°		0.6033
to 19°		9.5126 −10
		.1841
	1.528 Webers	

.0682
.6033
.1715

4.69 Webers for 45°

4 3/4 Webers for 45°

April 25 1878

Cu Nitrate in porous cup
1 4 12 H_2SO_4 in outside 2 re
re-analgamated

129 temp 15°

Daniells which yesterday
gave 125
today 128 temp 14°C
124R

Cu. Nitrate
135 R
131 L

Testing E.M.F.

Daniells
111 R
111 L

Nitrate Cu
109 R

2 cells together
221 R

Nitrate Cu. another solution
105 R
105 L Temp 20°
107 R to 21°C

Daniells 110 R

132

Daniells
199 R
1.02 Daniells

Nitrate Cu
200 R
199 R
1 to 12
Water Sulphuric Neutral
a weaker solution 199 / 1.7122
19 R Gold
1.02 Daniells

weaker solution
Nitrate
196
4 to 1
water H_2SO_4

Comp log 100 / Comp log 194
$\frac{2}{\bar{2}.7122} - 16$
$\bar{1}.7122$
log 199 2.2989
2.0111
1.02

Sulphate Cu
195 R
1 to 4
H_2O H_2SO_4

Daniells
199 R
Sulphate Cu Standard Daniells
194 R = 1 to 12

133

Daniells
120 R
1 Dan | 1 to 12 | 230 K
cum log 120 $\frac{2.}{\bar{1}.92207}$
$\bar{1}.92207$
$2.36172\,30$
191 .2824 2.28

Chromate
100 H_2O
12 Bicromate of potash
25 H_2SO_4
228
205
1 to 4
1.91 Daniells
232
1 to 12

Copper wound round the carbon which brings the deflection down to 205 — in contact with liquid

Nitric acid Grove 1.38

215 214 216 — 1 to 4

Bunsen carbon 1 to 4

215 216 — 1.80

T. 1.9207
2.3345
.2552

Cuming Nitric

115 218 — 112 3

Carbon

219.5

220

220 — 1.83

T. 1.9207
2.3426
0.2531

220 1.83 Daniells

Daniells 120

136

These measurements seem to be good and consistent. Yet they do not agree with the numbers given by Clark & Sabine

~~I take the~~

Perhaps in changing the Zn from dilute to concentrated H_2SO_4 ~~then~~ I did not give time enough for change of solution on surface

137

~~0.034~~

$C = 1$

$\frac{1}{2}$ 1 MΣ $\frac{1}{4}$

$\frac{1}{4} \times 4 = \frac{1}{2}$

$\frac{1}{2}$ current

4 $\frac{1}{4} 2 = \frac{1}{2}$

21

16 Cells $\frac{1}{16}$ Ohm 1 Ohm

16	Cells =	16 Ohms	16 MΣ
8		32 Ohms	8 MΣ
4		64 Ohms	4 MΣ
2		128 Ohms	2 MΣ
1		256 Ohms	1 MΣ

Measurement of Zinc Amalgamation

Standard Daniells

Conc Solution of sulphate of Zn. amalgamated Zn

conc Solution of $Cu SO_4$

electrotype Cu.

D = 100 L

Daniells 95 L

100 L

96 L

291

305

Standard Daniells

100 L

102 R

2 cells 192

1 of the 102 L

the other 84

186

3 cells 308

4 cells off scale

brought 4 cells back to 50 division

Gramme machine

Dynamometer

70 lbs when no current from Gramme, this from permanent magnetism

3' to the right "Fiducial"

210 L

6° 10'

3

6° 13'

210 = D

over 1.53 Ohms

Dynamometer gives 6° 7'

with No. 2 shunted

6° 3'

5.02 Ohms Total in circuit

5.25 Ohms Hot

This was the total in circuit

Daniells

50 R 5th R Reduced

Dynam $10^\circ 4' 9''$

295 L $10^\circ 5' 4''$

In current 70 K = Deflection

Total 4.4 Ohms in circuit.

1.5 Ohms

Daniells = 1.09 Volts

After Kohlrausch. I take this number as given on good authority and also as bringing my calculations above rather than below what may be the truth.

$C = \frac{E}{R}$

$\frac{210}{50} = 4.2$ Daniells E. M. F.

$\frac{4}{16.8}$

16.8	1.2253
1.5	0.1761
11.2	1.0492
1.09	0.0374
	1.0866

12.2 Webers $R = 5.25$ Ohms

$E = CR$

11.2	1.0492
5.25	.7202
58.8	1.7694 Daniell
64.1 Volts	1.8068

$C^2 = \sin D$

$C = \sin i$

$20 = 2i$

$C = \sin i$

$D = 5^\circ 3'$

sin 6° 3' 2 | 9.0228 -10

4.5114 -5

log .324 =

12.2 Webers

.324	1.5114
12.2	1.0866
	2.4248
.0290	2
	4.8496

2' 26" 2 | 6.8496 -10

3.4249 -5

Constant of Dynamometer.

$\bar{2}.4249$, comp = 11.5751 - 10

Divide the equare root of the sine of the deflection by the constant and the result will be the No of Webers

$\frac{295}{50} = 5.9$

4

23.6 Daniells

23.6	1.3729
1.5	.1761
15.5	1.1968
1.09	.0394
17.2 Webers	1.2362
	4.4
69.3 Daniells	1.1968
75.8 Volts	0.6435
	1.8403
	.0394
	1.8797

sin 10° 49' 2 | 9.2733 -10

1.6366

1.5751 -10

1.2117

16.2 Webers

146

16.2 Webers
over one Ohm
42. foot lbs

16.2	1,2117
16.2	1,2117
42.	1,1232
	4.0466

18100 foot lbs over 1 Ohm
say 20 candles
505 foot lbs. per candle
per minute

198 over 1.5 Ohms

Total 4.47

.2' Fiducial

16° 14'

16° 4'

New deflection

Did not get the resistance

again

280 4.3 ohms

13° 45'

1.27 ohms

14° 46'

285 = 4 cyl

4 Daniells, 49

21° 33'

20° 58' just on slowly

22° 25' just on at once when coils were welded

24° after bringing up by putting

Battery in line so that these results

1.3 Ohms in circuit

22° 25'

23°

23° 40

1.1 Ohms

total in circuit 2.7 Ohms

D = 20° 23'

2 | 19.54099 - 10
7.7704 - 5
11.57751 - 10
16.34555 - 15

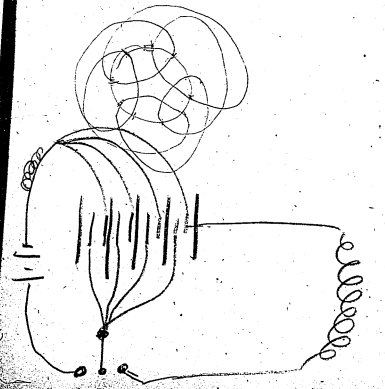
22.1 Webers 1.34555
.4314
2.7 1.7769 59.6

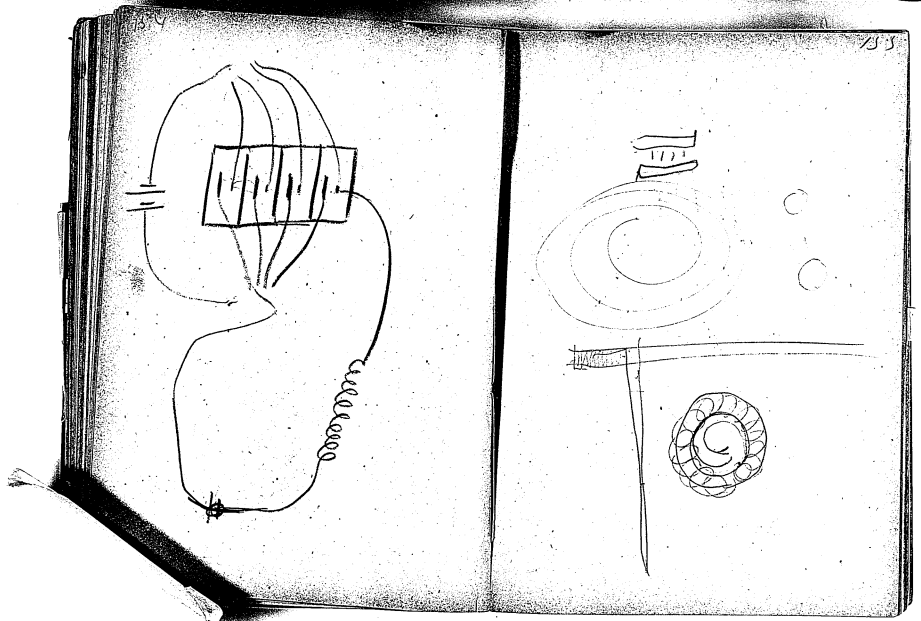
Speed 670

Total resistance	Webers	Volts
5.25 Ohms	12.2	64.1
4.4	16.2	75.8
2.7	22.1	59.8

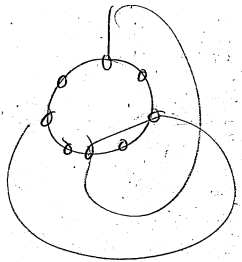
12.2	1.0864
12.2	1.0864
5.25	.7160
44.2	1.6454
34.200	4.5346
16.2	1.2095
16.2	1.2095
4.4	0.6435
44.2	1.6454
51.000	4.7079
22.1	1.3444
22.1	1.3444
2.7	0.4314
44.2	1.6454
58.200	4.7656

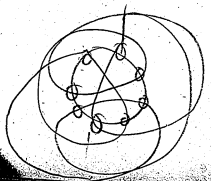
I want the curve of the Gramme machine. That is the relation of the amount of external resistance to the M. F.

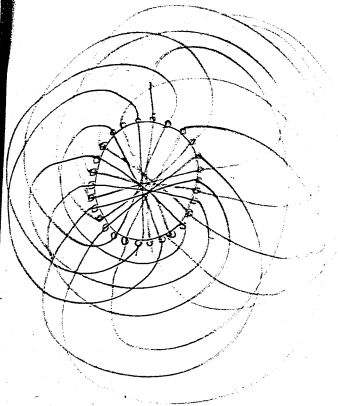




7°. 10'







154

2 2160 1

2155
79 8
79 6
111
553
6241
44
24964
24964

55) 2746 04 (

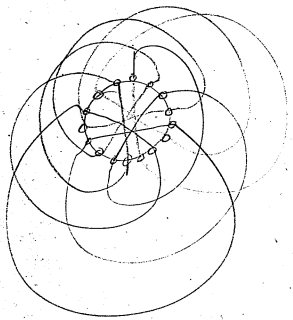
155 4 5
7
20) 1106 (55
100
106
100
6 2

7.3 : X : 20 : 158

55) 2746.04 (49.92 = 5
220
546
495
510
495
150
140

944 6 5

4.992) 33.000 (6
29952
3048
4992



155

160

981

$\frac{1}{981}$ Dyne ——— Force

$\frac{1}{981}$ Gramme through 1 Centimeter at Paris

This is a unit of Workor energy.

772

424 Kilo-metres
42400 - centi
2724000 - milli

~~42400 Centigramme millimetre~~

424000 mg gramme

1 ~~Gm~~ of H_2O heated 1° C

= 1 unit of Wk raised 424 metres
42400 Centi

~~Dyne~~ Erg = ~~Ene~~ Work against unit of force or Dyne

~~Dyne~~ = unit of force the force required to produce a velocity of 1 centi in one second acting on 1 Gramme

~~Dyne~~ Erg = work performed by the unit of force = Dyne in one second

= $\frac{1}{981}$ of the work performed in lifting 1 Gramme 1 Centi

= $\frac{1}{981}$ The work performed in lifting Gramme one Centimeter

The work required to raise 1 Gramme of water 1° C = The work required to lift the same weight one Gramme 42400 Centimeters

or 42400×981 Ergs

since one Erg = .981 of a gramme

42400	4.6274
981	2.9917
41600000	7.6191

4160×10^4 Centimeter-Gramme^2 / Sec^2

= Joules Equivalent

.003411 Grammes is the value of e for Zn, or the electro Chemical equiv. of 1 Weber of Current.

Favre & Silbermann give 714 Gram. Deg. C. as the amt. of heat developed by burning 1 Gramme of Zn in a Daniells cell.

Therefore the amount of work done by one Weber current passing through a Daniells cell =

$w = .003411 \times 714 \times 4160 \times 10^4$ Gram Cm / Sec

3.5330	
2.8537	
7.6191	
8.0058	

1.012×10^8 Gram Cm / Sec

The work performed by a unit of current is

107 $\frac{\text{Gram Cents}}{\text{Sec}}$

or $\frac{1}{10}$ of that found

Wiedermann's

.03411 Mm

I take the same example from Wiedermann

.03411 mg is the electro-chemical equiv. of Zn

or .00003411 Grammes

.00003411

C^2R $\quad C = \frac{\mathcal{E}}{R}$, $R = \frac{\mathcal{E}}{C}$

$\mathcal{E}$ $\quad \mathcal{E} = CR$

Work $= C\mathcal{E}$

The work done in a circuit is equal to the amt of heat given off by the consumption of the Zn.

$= e\,J\,W\,C$

e = electro-chemical-equiv.

J = Joules equiv.

W = Zn. that equiv.

C = Current in Webers

Work also $= C\mathcal{E}$

C = current

$\mathcal{E}$ = E.M.F.

If

A current ~~gives~~ being a certain amt. of zn.

$$a_3\ \partial w$$
$$e\ g\ c\ zn = \mathcal{E}\ C$$
$$e\ g\ zn = \mathcal{E}$$

not so

C on left is a numeral
C on right is a concrete no.

$$C = \frac{mm^{\frac{1}{2}}\ mg^{\frac{1}{2}}}{T}\ \text{amt. of elec}$$
$$\mathcal{E} = \frac{mm^{\frac{3}{2}}\ mg^{\frac{1}{2}}}{T^2}$$
$$C\mathcal{E} = \frac{mm^2\ mg^{\frac{1}{1}}}{T^3}\ \text{for a definite time}$$
$$C\mathcal{E} = \frac{mm^2\ mg^{\frac{1}{1}}}{T^2}$$

$$\text{Force} = \frac{mm\ mg}{T^2}$$

$$\text{Work} = \frac{mm^2\ mg}{T^2}\ T = C\mathcal{E}$$

Joule's equivalent is of the same denomination as work

$$\frac{mm^2\ mg}{T^2},$$

so it seems wrong to place it ~~opposite~~ not in an equation which has on the other side $\frac{mm^{\frac{3}{2}}\ mg}{T^2}$

$RE = 10^{12} \frac{mm^2 . mg}{sec^2} = C^2 R$

Joules equiv = see p. 162

$4160 \times 10^4 \frac{Centi^2 . Gram}{sec^2}$

$1 \frac{cm^2 Gm}{sec^2} = 10^{12} \frac{mm^2 mg}{sec^2}$

1 Gram of Sn will heat 769 or 7347 H_2O 1 deg C.

1 mg 769 mg H_2O

Joules equiv. does not depend of the denomination of the Mk since it is changed in both the unit to be raised of the material and of the H_2O.

— so that in changing from the $\frac{cm^2 Gm}{sec^2}$ the change of the cm. to mm. is all that counts.

∴ Joules equiv

= 4160×10^6.

— German unit of current deposits
One of Weber. unit = 0.1 a Weber but to Ag = Weber deposits .03411 mg in one sec
and

Water Daniells

$CE = 76.9$ or 734.7×10^{-3411}

$\times 4155 \times 10^{6}$

$= 1.09 \times 10^{11}$

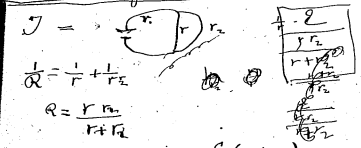
This seems to be all wrong since it would be of 10^{12} $\frac{mm^2\ mg}{Sec^2}$ or the unit of a Weber over an Ohm

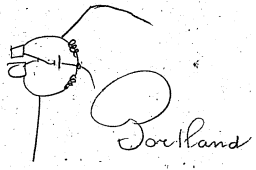
July 15.

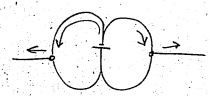
The EMF of a Daniells increases as the solution of Zn. is diluted about 2% chiefly.

Wiedemann Vol I P 250

Amalgamated Zn. has greater less EMF. than unamalgamated.







$R = \frac{r r_2}{r + r_2}$ =

$c : c_2 :: r_2 : r$

$C' = \text{Total}$ $\quad \vartheta_1 = \frac{\mathcal{E}(r + r_2)}{r r_1 + r r_2 + r_1 r_2}$

$c + c_2 = C'$

$c + c_2 : c_2 :: r_2 + r : r$

$c_2 = \frac{r C'}{r_2 + r}$

~~$\vartheta_2 = \frac{\mathcal{E} r}{r r_1 + r r_2 + r_1 r_2}$~~

$\vartheta_1 = \frac{\vartheta_2 (r + r_2)}{r}$ $\quad r_2 \gg r$

$\vartheta_1 = \frac{\vartheta_2 r_2}{r}$

174. Aug 6 1919

Tested Latimer Clark's standard cell by

Remarks. ———

He speaks of washing the Mercurous Sulphate until the yellow is completely removed. Lamson washed the white powder obtained by precipitating Mercurous Sulphate from the Nitrate by means of Sulphuric acid. It became more and more yellow instead of white - a trace of Sulphuric acid would instantly restore it to whiteness. He prepared the Sulphate as he did after the manner described by Mr. Clark, by boiling Hg in H_2SO_4

This ——— after 175

repeated washing gave a greenish ppt which was made white by addition of a trace of H_2SO_4. Mr. Clark distinctly says no trace of H_2SO_4 must be present on account of its altering the E. M. F. but if he procured a white powder after many washings it is proof that ~~none~~ some H_2SO_4 was present.

He speaks of the alteration due to temperature as being .055 of one per cent above 15.5° C and .08 below 15.5° C

which is ~~[illegible]~~ ing that taking the statement literally is most wonderful ~~[illegible]~~ that at an ordinary temperature there should be so sharp a change, on taking the statement scientifically that it means to be had measured the E. M. F. at 0°, 15.5° and 100° C and that the numbers express simply the the difference divided by the number of degrees between the ~~[illegible]~~ the figures given, it is extremely true. An error of 1/2 per cent may be introduced into calculations by

this ~~[illegible]~~ and I had five c.c. Cl. made and found that they ~~[illegible]~~ 2 to 3 per cent ~~[illegible]~~ the ~~[illegible]~~ ~~[illegible]~~ glycerides seem to cling in the pores and any tendency out also forces the mercury through the pores tending to ~~[illegible]~~ the ~~[illegible]~~ ~~[illegible]~~ very ~~[illegible]~~ and ~~[illegible]~~ and ~~[illegible]~~ The standard cell is much better, easier ~~[illegible]~~, more constant, and a more natural unit.

F. R. [illegible]

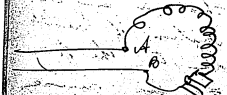
18 Oct 11, 1879

Regulation

To make a ten Ohm lamp equal to 100 Ohm

The current may be made to divide by a commutator in the cellar, revolved by an additional circuit so as to turn all the time

With a motor put in the circuit ~~that same current~~ If this is so arranged nine lamps are put in circuit with the motor in each house



a regulation may be effected, but the economy would be the same as if a resistance were not inserted when the motor was taken out. The Reason the same amount of energy must be given off from each lamp by the same current so that the drop of the E.M.F. must be the same from between the two extremities of the lamp, so that when was the total fall must be the same for the whole circuit ~~was 100 Volts~~ 900 Volts from A to B. If the law holds true that in any circuit the distribution of work is proportional to the fall of the E.M.F., as since

motor the same current is
~~the same~~
the same when the motor
is running as when the
~~there~~ there is only resis-
tance in the circuit.
~~and~~ the same fall of
E. M. F. will occur around
a lamp to denote the same
amount of energy given
off, that is 10 Volts, then
the 90 Volts fall in
the remainder of the cir-
cuit will represent the
same work given off
in either case.

Mr Edison proposes to have 153
in the cellar of the house an
arrangement ~~to~~ with say
10 commutators each one
connected with a lamp.
If each lamp is on 1/10 of the
time it will receive 1/10 of
the current that it would
if it were on all the time
that is a ten Ohm lamp
would take the place of
a hundred Ohm lamps
with such an arrangement.
This commutator must have
the same number of breaks
as there are lamps in the
house. If all the lamps are
on there will be no
spark.

In this way the general average of the house is taken. That taking a large number of lamps only 1/10 of them will be out at once.

If there are 1 Ohm conductor for every 10 lamps 1/10 of the energy will be lost in the conductors when all the lamps are on and a ~~proportional~~ ~~part~~ less proportion when less are on, for this each lamp will have the Co. for the neighboring houses & use.

5.5 Ohm
a stick 8 inches long
.060 inches diameter

5.5
36
330
165
1980

2/16
4

8 .010
.038
8
.248 surface

8 inches .010

10^8 Volt $= 10^5$ Meter Gramme / Sec.

$\frac{10^5 \times 2}{10^2} = 10^3$ Meter Gramme / Sec.

Table Ref Engg.

Thomsen p 419

68,376 heat units

16 grammes O

2 " H

68,920 Favre & Silbermann

1.44 Daniells cell

Cl. equiv. 35.5

Na. " 23

Dissolution Hydrogen Chloride

17,314 heat units

114,380 heat units developed in the production of 2 Grms of H by the action of Na

on a dilute solution of ~~HCl~~ Hydrogen Chloride

Sodium hydroxide combining with H. Cl gives

27,490 heat units

HC in dissolution with K_2O

17.314 heat units

68.376

An Erg is the unit of work a dyne the unit of force is the force which acting on one gramme for one second produces a velocity of one centimeter.

The unit of work is that which is required to overcome a resistance of a dyne over a centimeter.

In Paris the dyne is equal to the weight of $\frac{1}{981}$ gramme an erg the work required to raise $\frac{1}{981}$ gramme 1 Centimeter high.

$\frac{1}{2}$ Erg = $\frac{1}{981}$ Gr Centi

2.0083
0.98093
2.8676

1000 Ergs = $\frac{1000}{981}$ Gr Centi

= 1.019 Gr Centi

1,000,000 Erg = 1.019 Gr Centi

Meg Erg = 1.019 Gr Metre

= .01019 Kilo Metre

= .01019 X 7.23 Ft. Lbs

= .0737 Ft. Lbs.

This looks all right but does not seem to be so.

Erg mine 1.000,000,000 Ergs

= 1,000 Meg Ergs = 73.7 ft. lbs

10	·0737
100	·7370
1000	73·7000

Pickering says that in an Erg mine there are 7.46 Horse powers or that an Erg mine or that

7.46
33000
22380
2238
246,18000 ft lbs

Meg Erg = 246 ft lbs

Foot, lbs. in Meg Erg

73.7 Calculated

~~346.~~ Pickering

Mechanical equivalent heat

1390.8 ft lbs

Gr ~~degree~~ C°

1390.8 ft lbs 3.1432

33.000 4.5185
7.46 0.8727
3.6458

4420 ft. lbs

Pickering say it takes 7.46 to make 1000 Meg Erg or 1 Erg 9

4.42 foot lbs 1 Meg Erg

10' 1 Erg
1.0 Erg 1.00

425 G. M.

1390.8 ft lbs

3.1480.
7.1407

2.2837

1390.8 ft. lbs

3.1430
1.4840
4.62702 Centi lbs

42340

422.40 Kilo Metres
Gram
42240 Gramme Metres

4222 Gramme Metre

42240 Gramme Centi

4.6257
2.9912
7.6169

41400000.

41.4 Meg Ergo

422.4 2.6257
41.4 7.6169
1.0088

10.2 Gramme Metre

.0102 Kilo Metre
723
.0102
1446
723
.07346 foot lbs.

Jenkin

One absolute C.G.S. (Engl.) unit of work

= .00101 95 C.G at Paris

1000000 Mgs. 1019.5000000 C.G

Mag Grd = 1019.5 C.G

= 10.195 m G

= .01019 Kil. Meter

= .0737 ft. lbs

6.00

44.8200

50

2200

.0737

50

3685.000

500

60

30000

.0737

2000000

22111.0000

2,211 ft. lbs.

500 Megs Erg per second

is 2,211 ft. lbs per minute

Schwendler

says a candle from

2,211 ft. lbs per minute

Gr M.S = .10129 G.M

Gr C S = 10000

10000 Gr C S = 1 Gr M.S

∴ = .10129 G.M

1 000000 Erg = 10.129 G M

Meg Erg = .10129 K M

= .6737 ft. lbs

6.751.000 one pound of H2O

51,359,000 ft. lbs. pound H

9 5.751 in one pound of H2O

6.39

6.1172000

.737

60

44.220

3.063.9

1390. ft lbs Mechan Equiv heat Gr C° R

68.376

1390

6153840

194928

68374

9401 8,640 ft. lbs. from the beginning of 16 lbs of O with 2 of H. R

1 lb of H2O

11.502,300 ft. lbs of

in two pound of water

~~one lbs of water heated~~

To heat one pound of water 1° F requires

772.6 ft. lbs.

To heat one pound of water 1° C requires

1390.8 ft. lbs.

To heat one gramme of water 1° C requires

1390.8 ft. Grammes

1 Gramme = ~~1/1000~~ Kilo

1 Kilo = 2.2046 lbs

1 Gramme = $\frac{2.2046}{1000}$

= .0022046

1390.8 ft Grammes

= .0022046 × 1390.8 ft. lbs

3.34333

3.14329

.48662 . 30665

= 3.0665 ft. lbs

3.0665 ft. lbs

33.000
60
1,980.000 Horse power for an hour

6 Horse power of energy to decompose 1 lb of water which will make 1 lb of H and 8 of O

That is to take off make 1/9 lb of H.

~~To take~~ To make

$\frac{35.36}{16} = 2.21$

If it takes the same energy to separate Ch. from ~~H~~ as O from H it would require 6 Horse power to make 2 lbs about or ~~+ lbs~~ 3 Horse power to make 1 lb.

$\frac{196}{35} = 5.3$

Enough to combine with 2.7

$\frac{5.3}{2}$ lbs of Gold.

Theoretical.

22.000 Heat units in the production of H.Cl

68.376 H_2O
22 000
46,376 Cl. O

114.380 formation of Na. Cl with H. from H.Cl in H₂O
114.380
22.000

114.380
68.376
182.756

Sprague gives the No of foot lbs developed by the "gr. equiv" of Na in combining with Cl. as 18,764

a pound requires

6,764 × 7000 / 35.5

3.84510
8.44977
4.27332
6.56819

3,700,000. ft. lbs

2 Horse power about

183.756 mills

35.5 lbs C with one lb of H.

183.756	5.26411	
1390	3.14301	
comp 35.5	8.44977	
	6.85589	

7,120,000	6.85289
1,950000	6.29627
	.56012

3.6 H.P. required to make 1 lb. of Ch in one hour

Bait. Engg.

4.802	6841
7000	7000
33,614,000	53,687,000

1390
22000
2780000
278
30,580,000

183,756

35	1.54411
23	1.36017
	.28224
	6.56881
	6.85505

7,000000 ft. lbs Sprague

S Sprague

Picturing rays

1 litre of air weigh 1.2934

In a pound there are

453.59 Grammes

$\frac{453.59}{1.293} = 350.7$ litres

$= 398$ quarts $= 99.5$ Gallons

---

1 litre = 1000 CC.

16.38 CC = 1 cu inch

1 litre $= \frac{1000}{16.38}$ cu. inches

3

8.748579

1.748579

$=$ 61.06 cu. inches

350.7 litres

61.06

254498

1.748579

4.330779

21,420 cu inches

3.237549

1,09823

12.39 cu feet

,36441

2.31 feet on a side

Box

2 ft. 4 inches on a side will contain about one pound of air.

The combination of one ~~part of Na with 35.5 Grams~~ 23 Grammes of Sodium with 35.5 Grammes of Cl. is attended by the liberation of 94.847 heat units.

Watts after Favre & Silbermann

Thomsen 97.690

94.847

~~19.2,53.7~~

96,268

355 Grammes 96,268 Gr. C°

~~1390 ft. lbs~~

1390 ft. Gr

35.5 lbs 96,268 X 1390 ft lbs

96268

1390

8664120

288804

96268

133,812,520 ft. lbs.

133 812,000

355

376,9,000

33000

1,980,000 ft. lbs 1 H.P.

one hour

8.12649

1.55023

6.57626

.57626

.29667

1904 H.P. .27958

Mechan. Equivalent of heat 423.55 Gm. through 1 Metre =

1 Gm. H_2O one degree C.

1 Gm. H_2O 1°C. =

423.55 Gm. M.

7.233 ft. lbs in 1 Kilo Metre

.007233 ft. lbs in one Gm. metre

.007233 ft. lbs. in one Gm. Metre

~~9481~~

96.000 4.98227

423.55 2.62690

7.60917

.007233 .007233

.007233

4,066,000 g. m 7.60917

.007233 $\bar{3}$.

2.679 .00267 lb in Gramme

.373 Kilo in lbs

373. 2.51171

.007233 $\bar{3}$.85932

2.35 .37103

7.60917

7.98020

95,540,000

216 Heat Equiv. 1 Gramme

423.55 Gr M

Gr Kgt

423.55 × 3.281 = 2.62690 × 0.51610 = 3.14300

1390 Gr Kgt

1 lb H_2O 1°C

1390 ft. lb.

27

14 × 14 = 56 + 14 = 196

9.5 × 3.5 = 175 + 105 = 1212.5

12) 196 (16
12
76

13.8 × 3.2 = 5051 / 10102

13.8 × 1.1399 = 2.2798 + 1.1010 = 1.2696

3.7 × .5682 = 1.1364

12 × 2.1584 = 1.1364 = 1.0220

10.5

Motor Equation

$\mathcal{E}_B$ = ~~Strength~~ E.M.F. binding dont

$\mathcal{E}_m$ = E.M.F. Motor

R = Resistance Motor

$\frac{\mathcal{E}_B - \mathcal{E}_m}{R}$ = Current through Motor

$\frac{(\mathcal{E}_B - \mathcal{E}_m)^2}{R}$ = Work on resistance

$(\mathcal{E}_B - \mathcal{E}_m)$ = Fall of E.M.F. on resistance

$\mathcal{E}_m$ = Fall on motor

$(\mathcal{E}_B - \mathcal{E}_m) : \mathcal{E}_m :: \frac{(\mathcal{E}_B - \mathcal{E}_m)^2}{R} : X$

X = work on motor

$\frac{(\mathcal{E}_B - \mathcal{E}_m)\mathcal{E}_m}{R} = X$ work performed

$\frac{\mathcal{E}_B\mathcal{E}_m - \mathcal{E}_m^2}{R} = X$

$\frac{(\mathcal{E}_B - \mathcal{E}_m)\mathcal{E}_m}{R} \times \frac{R}{\mathcal{E}_B - \mathcal{E}_m} = \frac{\mathcal{E}_m}{1}$

The ratio of the work performed to the current is always the fall of E.M.F. due to the ~~contrary~~ E.M.F. of the ~~motor~~. $= \mathcal{E}_m$

$\frac{\mathcal{E}^2}{R}$ = Work

$\frac{\mathcal{E}}{R}$ = Current

Ratio work to current = $\mathcal{E}$

$$\frac{(E_B - E_m)E_m}{R} + \frac{(E_B - E_m)^2}{R} = \text{Total work}$$

$$\frac{E_B - E_m}{R} = \text{Current}$$

Ratio Total work to current

$$E_m + E_B - E_m = E_B$$

That is the total work used by a motor is proportional to the E. M. F between the binding posts

That is in the case of a motor or a lamp the ratio of work to current is always a constant so that a meter will measure the energy

consumed

The ratio of the work consumed by resistance is to that consumed by the armature is constant — the fall in the total resistance.

E. M. F.

The work given off by the motor is $\frac{(E_B - E_m)E_m}{R} = W$ $\frac{E_B - E_m}{R} = C$

so that $W = C E_m$

Nov. 17 1879

J. R. W. Starr

Fall in E.M.F. due to lamps.

~~Let~~ Suppose to

Let R_l = resistance lamp

R_c = " in conductor

$\mathcal{E}$ = E.M.F. of machine which is kept constant

n = number of lamps in multiple arc

X = E.M.F. at extremity of lamps

$$X = \mathcal{E}\frac{\frac{R_c}{n}}{\frac{R_c}{n}+R_l} = \mathcal{E}\frac{R_c}{R_c+nR_l}$$

$$= \mathcal{E}\frac{nR_c}{R_l+nR_c}$$

R_m = Resistance motor

$\mathcal{E}_m$ = E.M.F. of motor

$\mathcal{E}$ = E.M.F. Machine Constant

R_c = resistance conductor

X = E.M.F. at motor

n = no motors

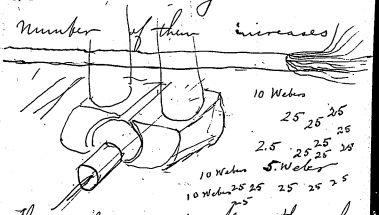
$$\mathcal{E} = \left(\mathcal{E}-\mathcal{E}_m\right)\frac{R_c}{\frac{R_m}{n}}$$

$$= \left(\mathcal{E}-\mathcal{E}_m\right)$$ writing ~~omitting~~

$\mathcal{E}_m$ not constant ~~working~~ that's the rub

$\mathcal{E}_m$ Emotor

The "Electromotive force of the emotor changes as the number of turns increases



That is less current flows through each one and they [illegible] less taking up less work

The energy used in work in a motor is

$\mathcal{E}_B$

The energy in useful work

$$\frac{\mathcal{E}_B \mathcal{E}_m - \mathcal{E}_m^2}{R}$$

$$\frac{(\mathcal{E}_B - \mathcal{E}_m)^2}{R}$$

$$\frac{\mathcal{E}_B \mathcal{E}_m - \mathcal{E}_m^2 + \mathcal{E}_B^2 - 2\mathcal{E}_B\mathcal{E}_m - \mathcal{E}_m^2}{R}$$

$$\frac{\mathcal{E}_B^2 - \mathcal{E}_B\mathcal{E}_m}{R}$$ Total work

W

$$\frac{\mathcal{E}_B^2 - \mathcal{E}_B\mathcal{E}_m}{R} \quad \frac{\mathcal{E}_B^2}{R}$$

226

E = Electromotive force
Electromotive force
Electromotive force
Electromotive force
Electromotive force
Electromotive Force.

E·M·F.

227

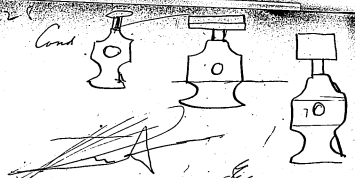
80
80
6400
44
27 6 00
25 60 00
100 | 28 16 9 | 2816
200
816
800
166
100
600

150 | 2816.00 | 18.70
150
1316
1200
1160
1050
1106

Portland

Jan

Cond



$\mathcal{E}$

$\frac{\mathcal{E}_m}{\mathcal{E}} = \frac{\mathcal{E} - \mathcal{E}_m \left(\frac{R_c}{R_m}\right)}{\mathcal{E}}$

$\frac{\mathcal{E} - \mathcal{E}_m}{\mathcal{E}} \frac{R_c}{R_m}$

$\mathcal{E} - \mathcal{E}_m \frac{R_c}{R_m} \frac{R_c}{R_m} \frac{R_c}{R_m} \frac{R_c}{R_m + R_c}$

$\frac{R_c}{R_m} \frac{R_c}{R_m} \frac{R_c}{R_m} \left(\frac{R_c}{R_m}\right) \frac{R_c}{R_c}$

multiply

Motor

$\mathcal{E}$ Lamps

$\mathcal{E} \frac{\frac{R_c}{n}}{\frac{R_L}{n} + R_c} = \mathcal{E} \frac{n R_c}{R_L + n R_c}$

Lamps

Lamps

$\mathcal{E}$ R_c

Lamps

Lamps Lamps

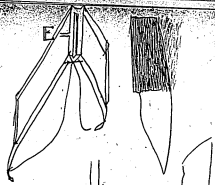
Lamps

Lamps

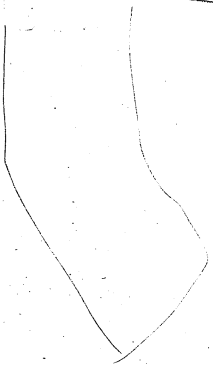
$\frac{R_c}{\frac{R_L}{n} + R_c}$

Lamp

Motor



1 Mile



600 Ohm
150 Ohms

.004
.008 2600
.016
.032
2600
2600

375
9.87
2.34

16) 1000 (62
96
40
00 4) 62
15.5) 60
16

250

~~$175~~ $175 $175
~~$175~~ $176 $175

4 hours
3 hours each day

365
3
1095

1000 hours
5000 feet
5.00 feet per year per burner

$2.50

80,000

250 | 8500 | 34
750
1000 | 102

3%
10 000
Conductor

$3.40
1.50
5.00
$13.42

$34
$15

$1.02
1.50
5.00
1.00

$13.42
.85
$219

217

13
5
.85

50 cts per thousand

~~$2.00~~

60 3.00

$3.40
1.50
1.02
1.50
3.00
1.50
5.00
1.00

$17.92

1.8

250 | 450
250
1800

3 | 150

3 | 150

1650
1320
330
165
165

1650
1320
330
165
165

1650
1320
330
165
165

~~9 90 cts~~ 36,500

365 ×100

~~4 hours a day~~

5 hours each day

average burner on

~~maximum~~

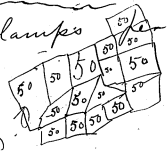
365 / 5 / 1825 hours

1800 / 5 / 360 H

1800 hours

1800 hours a year

8 lamps to H. P.



Cost Horse Power

$34.

$15

$0%

~~Boilers~~ Engines

Boilers

~~Engines~~

$40

50
50
2500
4
1000

3 cts an hour per H. P.

6
18
5
90 cts

We shall have ten lamps per horse power indicated — easily 100 ohms each

~~Cost of Generator per horse power~~

$34	Engine	700 per horse power
$15	Boiler	$37.000 per horse power
		$37.000
$3.40		per horse power
$1.50		
$4.90	Investment Boiler & Engine	
	per horse power	$25.000
		$25.000

2 Dynamo Machine

60 lights per machine

$180. a machine $26.000 $25.000

$3.00 Investment Dynamo

Conductor

$5.00 per lamp

$12.90 Investment per lamp

Depreciation

$10 a	Engine	.10
1.5 a	Boiler	.15
10	Dynamo	.10
	Conductor	.05
		.45

1800) 1.74 .0096 1.29

1.7400 .0006 $1.74 10%

.10	1800	1.74 00 (96 cts.
.15		16200
.15		12000 10%
.05		10800 10%
.45		1200 10%
Brushes		$25.000 $25.000
Commutator		
Conductor		$25.000 $25.000

5 96 cts per 5000 feet

~~.0019~~ cts $25.000 $25.000

20 cts per 1000 feet

$2.000 per 1000 ft investment

34 cts per 1000 feet

paying 10% on plant and depreciation

1000 ft

2 cts per H.P

2 cts per 5 feet

200
40 cts. per 1000 feet

40 cts. per 1000 feet 1000 1000 1000 feet

2 cts per H.P. $ $

$180 $ $ $

2 5 2000 3 000000 3000 $7.50 $7.50

$7 $7.50 $7.50 $7.50 $7.50 $7.50

60 | 4.50 $22 $22 $22 $22 $22

$7.50 $22 a hour

.140

$22 $22

$20 $20 $22 $300

$20 $12

$300

A $350 $350 $400 $400 $400

$5.00 $400

35 M a 1000

45 M

$80 65 M a 1000

2 5000 25 c

250

300

$400 900 $1000

$360000 $90

50 cts. a 1000

3 000000 50 cts. for

30 000 cts 1000

= 6 per H. P.

700 X 200 feet

A 350 feet
7
2450
2
590 feet

30 Houses

.0047 × 30 = .1410
10.5 lbs × 30 = 315.0 lbs

G 15 Houses 460 feet
2
920 feet

.0075 × 15 = 375
75
.1125

26.5 × 15 = 1325

B 30 houses
350
avenue 100
245
695
2
1390 feet

.0112 × 30 = .3360
60 lbs × 30 = 1800 lbs

300 150
600
1200

F 30 Houses
350
50
140
540
2
feet 1080

.0087 × 30 = .2610
34.5 × 30 = 1035.0

C.C' 30 Houses
Corner
350
50
200
75
245
920
2
1840

.8940
105.8 × 60 = 6348.0

G 30 houses
350
50
200
75
140
815
2
1630

.6132 × 30 = .3960
83 × 30 = 2490

262

DD' 60 Flames

350
50
200
75
200
875
2
1750

·10181
60
10860

156
60
9360

675
245
1120
2
2240

H 3 w lights

875
140
1015
2
2030

·0172
30
·5260

142
30
4260

EE' 3 w lights

1075
245
1320
2
2640

·0212
30
·6360

217·8
30
65240

Lamps

A	300	·1410		
J	150	·1125	315	
B	300	·3360	132	
F	300	·2616	1800	
CC'	600	·8940	1095	
G	300	·3960	6348	
DD'	600	1.0560	2490	
H	300	·5260	9360	
EE'	300	·6360	4260	
	3150	43885	32324 Cu	

3150) 32324 (10.2
3150
8240

10.2 lbs of Cu per lamp

10.2
30
3.06 for Cu.
5.00 with box

$20 $50 a year

$12.50 per quarter

3 hours

5 4 1/6 60 each per month

3 1/2 hours

5 1/2 hours

365 1 hour a day

365

730 2 hours

365

1095 3 hours

365

1460 4 hours

360

1406 5 hours

365

2190 6 hours

365

2555 7 hours

730
365

365
3
1095

Dynamo Work

100 $200

500 feet $4.00

Engine & Boiler 5.00

Conductor 5.00

Building 5.00

19.00

Burners Meters &c 1.00

$20.00

Interest $2.00

Depreciation $2.00

$4.00 a year

4 hours

.277

55 cts per M

1440) 4000 (2.77 cts per hour
2880
11200
10080
1120

H. P. 1

Coal under boiler

$5.00

3 lbs.

3 / 2240
746 H. P.

746) 50000 (.67
4476
5240

.67 cost steam per H. P

$ per H. P.

.084 cts per lamp per hour

200
16800 cts per M

10000 lamps one station

50000 M
4
200 M per day

2 Engineers 4
2 Firemen 12
4 Wipers 8
2 Regulators 4

200) 2800 (14 cts

$28

165 Wanel

85 cts per M
16.8
$\$$
85.18 cts per M paying
10% on capital 10% depreciation
18 per H. P
$5.00 for conductors
4 hours a day
five feet
10000 lamps a station

16.8 $\$$ per H. P
14.
4 3 08 cts in holder
77
23.1 cts

Dynamo 245

$200 8 per H. P
60 lights 1/10 H. P.

1/10 H. P 60/204
1/20 $3.33 per lamp Dynamo

Wear and tear 5%
1.665

Engine 34 per H. P
$4.125 per lamp
15.37

Boiler $15.
$1.87 per lamp

Conductors 5.00
Lamps &c 1.00

3.33
4.12
1.87
5.00
$14.32

Cost 5.00
Building $20.32 19.32
1 00

Depreciation

3 ~~10%~~	on Engine	~~.124~~
5 %	on Dynamo	~~.166~~
10 %	Boilers	.187
2 %	Conductors	.110
10 %	Lamps	.110
Taxes & Insurance 5 %		.50
		1.177

1.17
2.03
3.20 per kwmer per year

3 hours a day

1075) 3200 (.3 cts
3215

1075) 11175 (109
10 75
9500
200
3
60 cts per M

216 cts

4 hours each day

1440) 3200 (2 .23
2880
320 : 200
4600

46 cts per M

5 hours a day

1805) 3200 (1 7
1805
13950 : 20

34 cts per M

6 hours a day

2170) 3200 (1 4
2170
10300

24 cts per M

1440) 11176 (7 1
10080
1620
142

1805) 11200 (6 5
10830
@ 700
P
13

272 10000 lamps

16.6 cts per M

coal at $5.00 under timber

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labor $28 per day

A day	3 hours	$9.33	per hour
	4	7.00	"
	5	5.60	"
	6	4.66	"

10000 lamps

3 E

3 M per hour

3 hours 50) 9.33 (18 cts per M

50

433

4 hours 14 cts per M 273

5 hours 11.2 "

6 hours 8.3 cts

Oil waste 4c

3 cts per M

3 hours
60.
16.8
18.
5.
99.8 cts per M
39 cts in holder

4 hours
46
21.8
14
81.8 cts per M
35.8 in holder

5 hours
34.
21.8
11.2
67.0 cts per M
33 cts in holder

6 hours
28
21.8
8.3
58.4 cts per M
29.3 in holder

Management

1/2 of 28 = 14 a day

8

$100.8

Cost with Assortment
39
21
60 cts per M

88 cts

3 men 1 hr.

35.8
14.2
50.0 cts

72.7 cts

33
13
46 cts

62.3 cts

176

15.10

3650
5
18.250

4,000,000

40000000

12
50
760

60 | 16 00 (
#26

760 | 16.000 (2.2.3
1520
1800
1520
2800

277

80 | 100 (
#12.5 Bottom set
12.5 Ground and Flash
#25.00 Bricking on

4.25
85
4
330

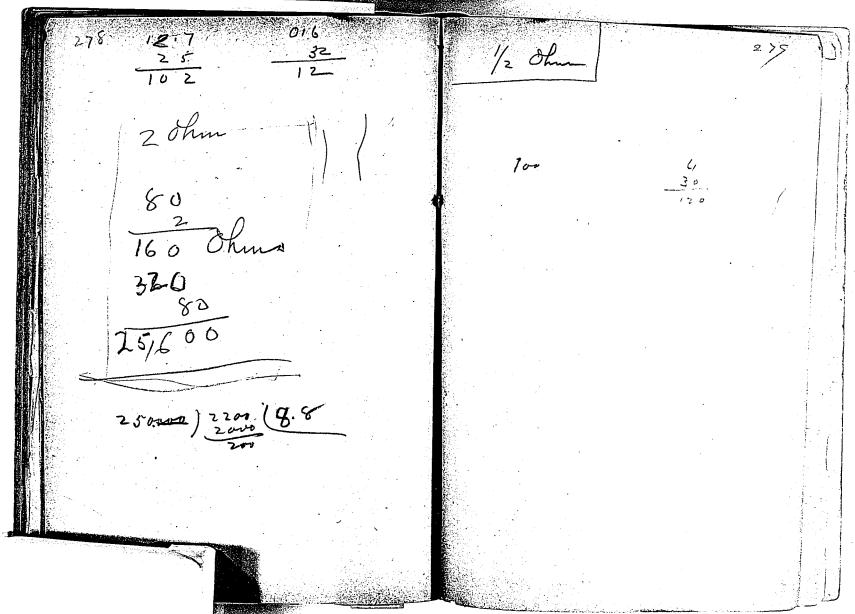
.435
87
84 6

5 | 10.10
202
6

802
320
130

165
33
132

167
334
1386


278
12·7
2 5
1 0 2
0·16
32
12
2 Ohm
80
2
160 Ohms
320
80
25600
250 mm) 2209. (8.8
2000
209
1/2 Ohm
275
100
4
30
120

24

3 lbs per N. 10

10
30
150 as Ans

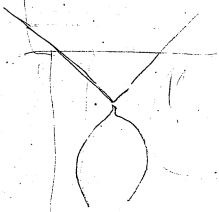
3
3
441
5
120

44.3 per 1000

3.00 / 2240 | 3.000 (.00134
2240
760
6720
8400

.00134
44.3
2

218 = 20



2240 | 5:000.000200
4480
20000
44.3
.0022
.0886
2